USER MANUAL   V1.04

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Scavenger Transmitter Module
STM 31x / STM 31xC

December 10, 2012

Observe precautions! Electrostatic sensitive devices!

Patent protected:
WO98/36395, DE 100 25 561, DE 101 50 128,
WO 2004/051591, DE 103 01 678 A1, DE 10309334,
WO 04/109236, WO 05/096482, WO 02/095707,
US 6,747,573, US 7,019,241

REVISION HISTORY

The following major modifications and improvements have been made to the first version of this document:

No	Major Changes
0.5	Initial version
0.90	New drawings added; Agency approvals added; new charging circuitry added; editorial changes
0.91	Chapter 3.3 added
0.95	Parameters of A/D converter corrected and specified in more detail; charging circuitry modified; editorial changes
0.99	Pin for connection of backup battery changed; ICHAR modified in 2.4 and s.5; section 3.4 inserted; update of drawings
1.00	Editorial changes
1.01	Block diagram and pin description modified; Application note for analog measurement added; Configuration options modified
1.02	Remark added in 3.5; additional remarks in 2.11; Label information modified in chapter 5; Figure corrected in 3.1; Circuit diagram added in 6; Shelf life added in 1.4; supply voltage for programming added in 2.2; Conducted output power replaced by radiated output power in 1.2; programming interface added in 2.3.3; other editorial changes
1.03	Specification of shelf life improved; figure added in 3.3.1; Chapter Related Documents added.
1.04	STM 330 description (page 4) changed to STM 31x

Important!

TABLE OF CONTENT

1   RELATED DOCUMENTS

This document describes operation of STM 31x / 31xC modules with their built-in firmware. If you want to write own firmware running on the integrated micro controller or need more detailed information on the Dolphin core please also refer to

- Dolphin Core Description
- Dolphin API Documentation

For mechanical integration please refer to our 3D drawings found at
http://www.enocean.com/en/enocean_modules/stm-310/

In addition we recommend following our application notes, in particular

- AN102: Antenna Basics – Basic Antenna Design Considerations for EnOcean based Products
- AN314: Rail-to-Rail Sensor Applications using the STM 31x

2   GENERAL DESCRIPTION

2.1   Basic functionality

The extremely power saving RF transmitter module STM 31x of EnOcean enables the realization of a wide range of wireless and maintenance free sensors such as temperature sensors, humidity sensors, or room operating panels.

Power supply is provided by a small solar cell, an external energy harvester, or an external 3 V back-up battery. An energy storage element is installed to bridge periods with no supply from the energy harvester. The module provides a user configurable cyclic wake up.

After wake up, the external sensors are supplied and after a configurable delay (default 2 ms) the internal microcontroller reads the status of the connected sensors. A radio telegram will be transmitted in case of a change of any digital input value compared to the last sending or in case of a significant change of measured analogue values. In case of no relevant input change a redundant retransmission signal is sent after a user configurable number of wake-ups to announce all current values. In addition to the cyclic wake-up, a wake up can be triggered externally using a wake input or the internal LRN button.

Features with built-in firmware

- Pre-installed solar cell (except STM 312/STM 312C)
- On-board energy storage and charging circuit
- On-board LRN button
- On-board TX indicator LED
- 20 pin connector for external sensors
- 3 A/D converter inputs
- 3 digital inputs
- Configurable wake-up and transmission cycle
- Wake-up via Wake pins or LRN button

Product variants
- STM 310/310C: Variant including solar cell and whip antenna
- STM 311/311C: Variant including solar cell and helical antenna
- STM 312/312C: Variant including whip antenna but no pre-installed solar cell

Features accessible via API
Using the Dolphin API library it is possible to write custom firmware for the module.
The API provides:
- Integrated 16 MHz 8051 CPU with 32 kB FLASH and 2 kB SRAM
- Various power down and sleep modes down to typ. 0.2 µA current consumption
- Up to 13 configurable I/Os
- 10 bit ADC, 8 bit DAC

2.2   Technical data

Antenna	whip or helical antenna installed
Frequency	315.0 MHz (STM 31xC)/868.3 MHz (STM 31x)
Radio Standard	EnOcean 868 MHz/315 MHz
Data rate/Modulation type	125 kbps/ASK
Conducted Output Power	STM 310, STM 312: +8 dBm[1] (EIRP) ± 2.5 dB[2]
	STM 310C, STM 312C: +92 dBµV/m[1] ± 2 dB[2]
	STM 311: +5 dBm[1] (EIRP) ± 2.5 dB[2]
	STM 311C: +92 dBµV/m[1] ± 2 dB[2]
Power Supply @ VDD	Pre-installed solar cell (except STM 312 / STM 312C)
	Illumination 50-100000 lux
	2.1 V–5.0 V, 2.6 V needed for start-up
Initial operation time in darkness @ 25°C	typ. 4 days, min. 60 hours
	if energy storage fully charged, wake-up every 100 s, transmission of telegram every 1000 s on average [3]
Operation start up time with empty energy store	typ. 2.5 min @ 400 lux / 25°C
	incandescent or fluorescent light
Input Channels	3x digital input, 2x WAKE input , 3x analog input
	2x analog reference input
	Resolution: 3x 8 bit or 1x 10 bit, 1x 8 bit, 1x 6 bit
Connector	20 pins, grid 1.27 mm, □ 0.4 mm
Radio Regulations	R&TTE EN 300 220 (STM 31x)
	FCC CFR-47 Part 15 (STM 31xC)

2.3   Physical dimensions

PCB dimensions	43±0.2 x 16±0.3 x 1±0.1 mm
Module height	8 mm
Weight	3.5 g (STM 312) – 6.4 g (STM 311C), depending on variant

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[1] Measured in test laboratory, measurement uncertainty 2.7 dB
[2] Tolerance of measurement in production at 50 Ω
[3] Full performance of the PAS614L energy storage is achieved after several days of operation (up to two weeks) at good illumination level. Performance degrades over life time, especially if energy storage is exposed to higher temperatures. Each 10 K drop in temperature doubles the expected life span.

1) Leiterplatten Gesamtdicke mit Leiterbahnen und Lötstoplack
PC board total thickness with conductor paths and solder resist

2) Toleranz für Fräskante:
tolerance for milled edge: 16 ± 0.2

3) Toleranz für Bohrungsabstand (ø2.5±0.05): 16 ± 0.1
tolerance for hole pitch (ø2.5±0.05): 16 ± 0.1

4) Toleranz für Ritzkante: 43 ± 0.3
tolerance for score edge: 43 ± 0.3

5) Toleranz für Bohrungsabstand: 43 ± 0.1
tolerance for hole pitch: 43 ± 0.1

6) restliche Bauteilehöhe max. 1.5mm
remaining component height max. 1.5mm

Versatz / displacement

	Toleranz / tolerance
Fräskante zu Bohrungen milled edge to holes	±0.2
Fräskante zu Leiterbild milled edge to conductive pattern	± 0.3
Ritzkante zu Bohrungen score edge to holes	± 0.3
Bohrungen holes	± 0.1
Bohrungen zu Leiterbild holes to conductive pattern	± 0.15

Bauteileseite
component side

Sperrfläche für Bauteile (Bauteile können bis an Sperrflächen angrenzen)
blocked surface for components (components can boarder on blocked surfaces)

Solarzelle
solar cell

Fräskante
milled edge

Ritzkante
score edge

EnOcean GmbH

A46-C01

Leiterplatte STMHW310C
PC board STMHW310C

2.4   Environmental conditions

Operating temperature	-20 °C … +60 °C
Storage temperature	-20 °C … +60 °C, recommended[4]: +10 °C…+30 °C, <60%r.h.
Shelf life (in absolute darkness)	36 months after delivery[5]
Humidity	0% … 93% r.h., non-condensing

⚠ The module shall not be placed on conductive materials, to prevent discharge of the internal energy storages[5]. Even materials such as conductive foam (ESD protection) may have negative impact.

2.5   Ordering Information

Type	Ordering Code	Frequency
STM 310	S3001-D310	868.3 MHz
STM 311	S3001-D311	868.3 MHz
STM 312	S3001-D312	868.3 MHz
STM 310C	S3031-D310	315.0 MHz
STM 311C	S3031-D311	315.0 MHz
STM 312C	S3031-D312	315.0 MHz

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[4] Recommended for maximum life of energy storage capacitor
[5] Deep discharge of the PAS614L energy storage leads to degradation of performance. Therefore products have to be taken into operation after 36 months. At least the PAS614L needs to be recharged to 2.1 V.

3   FUNCTIONAL DESCRIPTION

3.1   Simplified firmware flow chart and block diagram
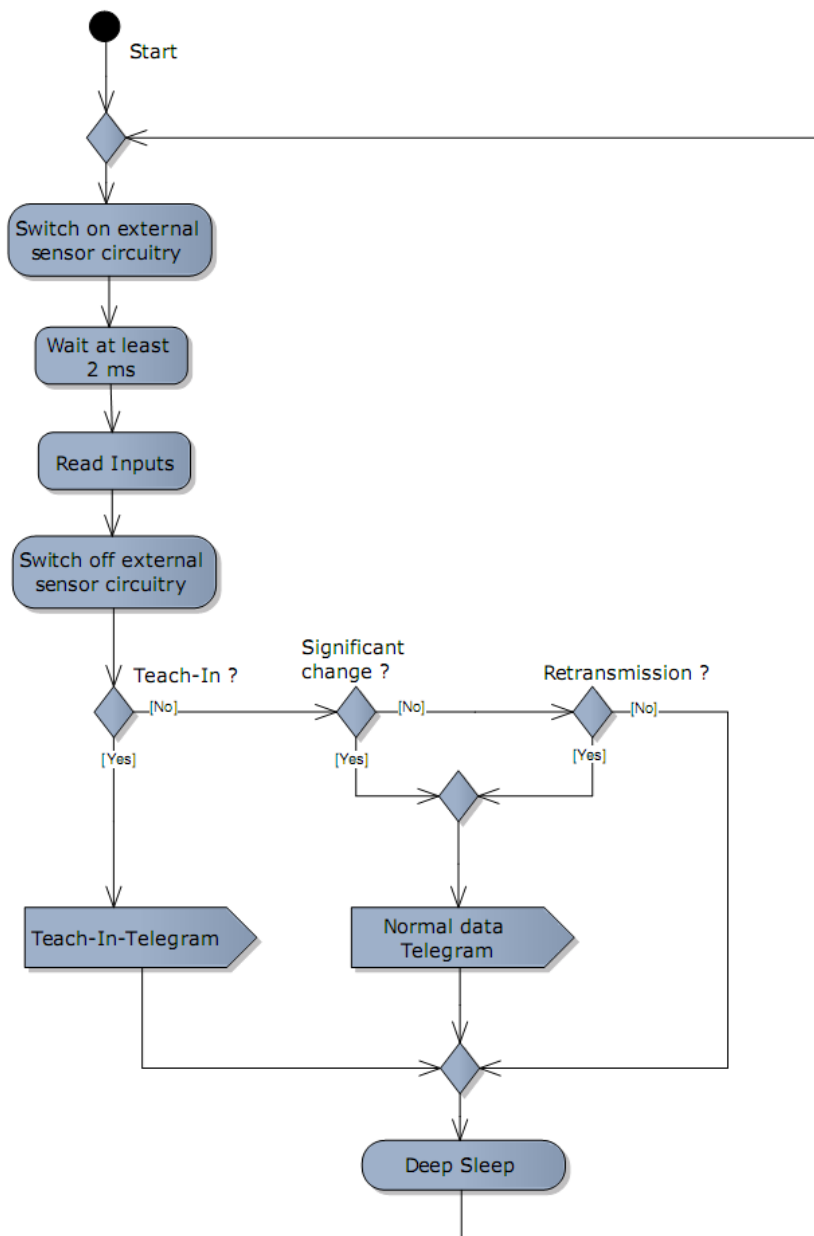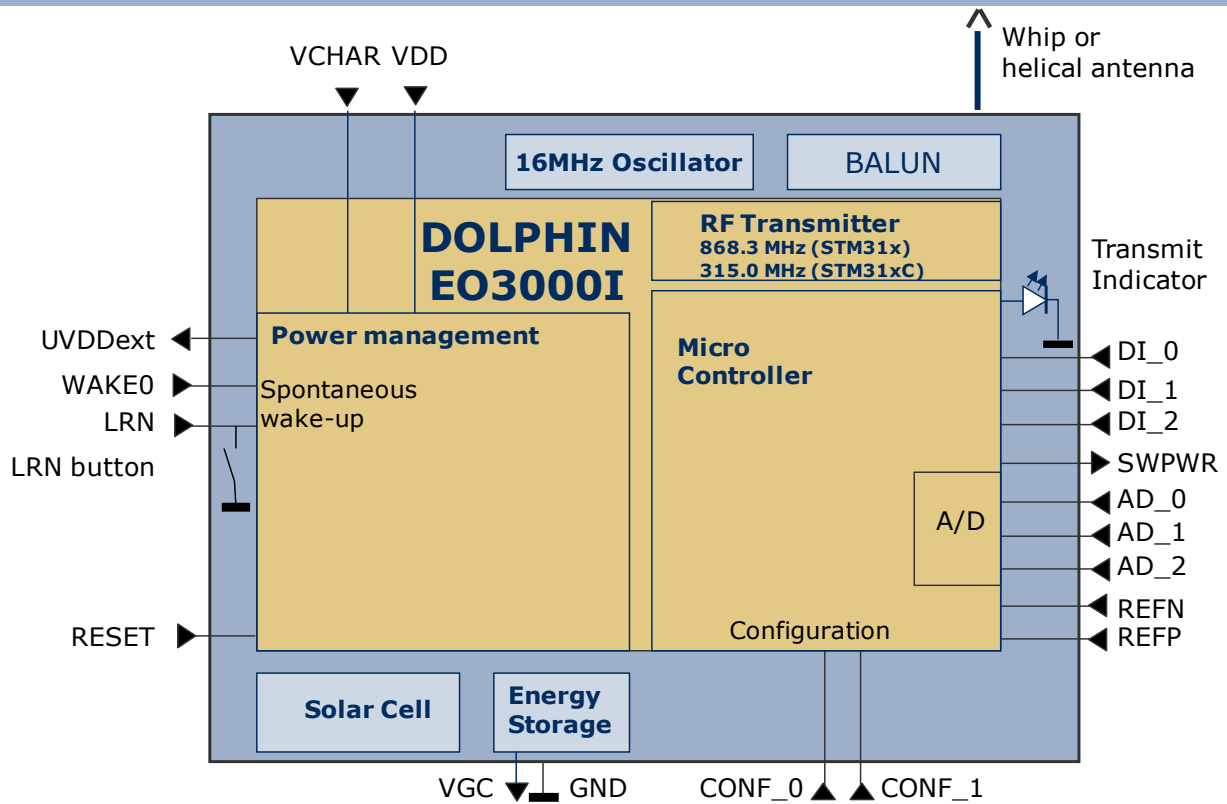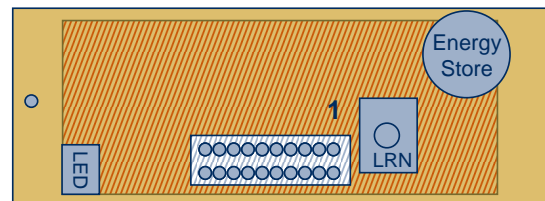
3.2   Pin out

The figure above shows the pin out of the STM 31x hardware. The pins are named according to the naming of the EO3000I chip to simplify usage of the DOLPHIN API.
The table in section 3.3 shows the translation of hardware pins to a naming that fits the functionality of the built-in firmware.

3.3   Pin description and operational characteristics

STM 31x Hardware Symbol	STM 31x Firmware Symbol	Function	Characteristics
GND	GND	Ground connection	
VDD	VDD	Supply voltage	2.1 V – 5.0 V; Start-up voltage: 2.6 V Maximum ripple: see 3.6 Not available at pin header. Connection of external 3 V battery possible. See 4.4.
		Supply for programming I/F	Recommended supply voltage for programming 3 V
VCHAR	VCHAR	Charging input	Input for an external energy harvester (for use in STM 312) or a battery. See 3.10.
		Supply for programming I/F if VDD cannot be used.[6]	Recommended supply voltage for programming 3.3 V – 3.6 V
VGC	VGC	Voltage Gold Cap	Connection of additional external energy storage. See 3.10.
SWPWR (= switched DVDD of EO3000I)	SWPWR	DVDD supply voltage regulator output switched via transistor controlled by EO3000I ADIO5 pin.	1.8 V. Output current: max. 5 mA. Supply for external circuitry, available while not in deep sleep mode. SWPWR is switched on 2 ms (default) before sampling of inputs and is switched off afterwards. The delay time can be configured, see 3.7.2 (needed for stabilization of sensors)
UVDDext (=UVDD of EO3000I with 1.8 MΩ in series)	UVDDext	Ultra low power supply voltage regulator output	Not for supply of external circuitry! For use with WAKE pins only, see section 4.1. Limited to max. 1 μA output current by an internal 1.8 MΩ resistor!
IOVDD (not available at pin connector)	IOVDD	GPIO supply voltage	Internal connection to EO3000I DVDD (typ. 1.8 V) See 3.3.1.
RESET	RESET	Reset input Programming I/F	Active high reset (1.8 V) Fixed internal 10 kΩ pull-down.
PROG_EN	PROG_EN	Programming I/F	HIGH: programming mode active LOW: operating mode Digital input, fixed internal 10 kΩ pull-down.

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[6] E.g. if module shall be programmed or configured via pin connector.
If a bed of nails fixture for programming is available VDD should be used instead of VCHAR.

ADIO0	AD_0	Analog input	Input read ~2 ms after wake-up. Resolution 8 bit (default) or 10 bit. See also 3.7.2.
ADIO1	AD_1	Analog input	Input read ~2 ms after wake-up. Resolution 8 bit (default) or 6 bit. See 3.7.2.
ADIO2	AD_2	Analog input	Input read ~2 ms after wake-up. Resolution 8 bit. See 3.7.2.
ADIO3	REFN	Negative reference input	Input is read ~2 ms after wake-up and is interpreted as negative voltage reference See 4.2
ADIO4	REFP	Positive reference input	Input is read ~2 ms after wake-up and is interpreted as positive voltage reference See 4.2
ADIO6	DI_2	Digital input	Input read ~2 ms after wake-up. See 3.7.2. Internal pull-up
ADIO7		Programming I/F	Leave open
SCSEDIO0	DI_0	Digital input	Input read ~2 ms after wake-up. See 3.7.2. Internal pull-up
		Programming I/F	
SCLKDIO1	DI_1	Digital input	Input read ~2 ms after wake-up. See 3.7.2. Internal pull-up
		Programming I/F	
WSDADIO2	CONF_1	Encoding input	Configuration interface. Leave open or connect to GND. See 3.7.1. Internal pull-up
		Programming I/F	
RSDADIO3	CONF_0	Encoding input	Configuration interface. Leave open or connect to GND. See 3.7.1. Internal pull-up
		Programming I/F	
WAKE0	WAKE0	Wake input	Change of logic state leads to wake-up and transmission of a telegram. Must be connected to UVDDext or GND! At time of delivery WAKE0 is connected to UVDDext via a jumper at the connector. See also 4.1.
WAKE1	LRN	LRN input	Change of logic state to LOW leads to wake-up and transmission of teach-in telegram. Internal pull-up to UVDD. See also 3.7.2, 3.8.2, and 4.1.

3.3.1 GPIO supply voltage

The IOVDD pin of EO3000I is internally connected to DVDD. For digital communication with other circuitry therefore a voltage of 1.8 V has to be used. While the module is in deep sleep mode the microcontroller with all its peripherals is switched off and DVDD, IOVDD, and SWPWR are not supplied.

⚠ If DVDD=0 V and IOVDD is not supplied (e.g. while in sleep mode), do not apply voltage to ADIO0 to ADIO7 and the pins of the serial interface (SCSEDIO0, SCLKDIO1, WSDADIO2, RSDADIO3). This may lead to unpredictable malfunction of the device.

⚠ For I/O pins configured as analog pins the IOVDD voltage level is not relevant! See also 3.3.2.
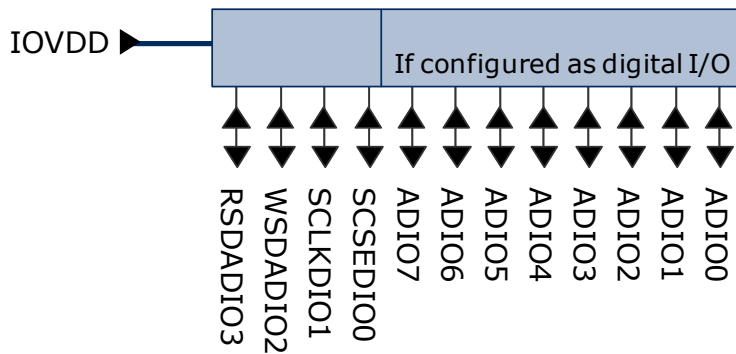
3.3.2 Analog and digital inputs

Parameter	Conditions / Notes	Min	Typ	Max	Units
Analog Input Mode (with external circuitry as described in 4.2)					
Measurement range	Single ended	REFN		REFP	
Input coupling			DC		
Measurement bandwidth[7]			62.5		kHz
Input impedance	Single ended against GND @ 1 kHz	10			MΩ
Input capacitance	Single ended against GND @ 1 kHz			10	pF
Effective measurement resolution			10		Bit
10bit measurement					
Offset error			0		LSB
Gain error			0		LSB
INL			+0 -15[8]	+0 -30[9]	LSB
DNL				±0.5	LSB
8bit measurement					
Offset error			0		LSB
Gain error			0		LSB
INL			+0 -4		LSB
DNL				±0.5	LSB

Offset Error: Describes the offset between the minimal possible code and code 0x00.

Gain Error: Describes the offset between maximum possible code and full scale (e.g. 0x3FF for 10bit measurements).

Integral Non-Linearity (INL): Describes the difference between the ideal characteristics and the real characteristics. Only values between minimum and maximum possible code are considered (excluding offset error and gain error).

Differential Non-Linearity (DNL): Measures the maximum deviation from the ideal step size of 1 LSB (least significant bit).

Effective resolution: Results from the signal-noise ratio of the ADC and is given in Bit. The number describes how many bits can be measured stable. The criterion selected here is that the noise of DNL is <±0.5 LSB.

Measurement Bandwidth: The measurement bandwitdh is internally limited by filters. A quasi static signal must be applied as long as the filter needs to settle. SettlingTime= 1/(MeasurementBandwidth)*ln(2^resolution[Bit])

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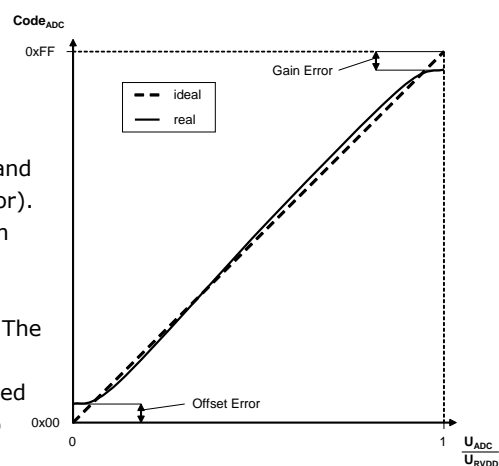
[7] 3 dB input bandwidth, resulting in 111 µs settling time to achieve a deviation of an input signal <1 LSB (<0.098% @ 10 bit resolution).
[8] At +25°C
[9] At -25°C

Parameter	Conditions / Notes	Min	Typ	Max	Units
Digital Input Mode					
Input HIGH voltage		2/3 IOVDD			V
Input LOW voltage				1/3 IOVDD	V
Pull up resistor	@IOVDD=1.7 … 1.9 V	90	132	200	kΩ

3.3.3 Programming Interface

Symbol
VDD
GND
PROG_EN
RESET
SCSEDIO0
SCLKDIO1
WSDADIO2
RSDADIO3
ADIO7
ADIO6 Only if in addition to programming I/F a serial interface is needed
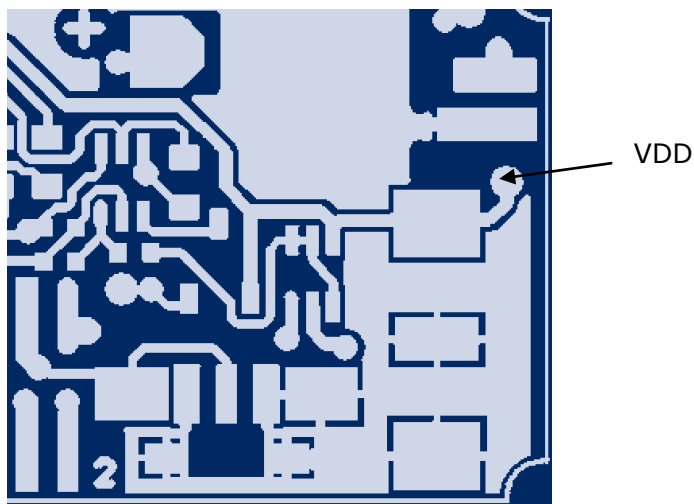
Top layer

The list above summarizes the pins needed for programming. VDD is not available at the pin connector. The position of the pad for VDD is shown in the figure above.

If VDD is not accessible, e.g. because the module shall be programmed via the pin connector, please use VCHAR instead of VDD (see 3.3).

The positions of the pads needed for programming are available from EnOcean as Gerber files (STM3XY(C)_05.GTL and STM3XY(C)_05.GK0).

3.4   Absolute maximum ratings (non operating)

Symbol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD	-0.5	5.5	V
VGC	Voltage gold cap	1.5	3.3	V
VCHAR	Supply voltage from external energy harvester	0	6	V
ICHAR	Supply current from external energy harvester		45	mA
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	-0.5	2	V
VIND	Voltage at RESET, WAKE0/1, and every digital input	-0.5	3.6	V

3.5   Maximum ratings (operating)

Symbol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD and VDDLIM	2.1	5.0	V
VGC	Voltage gold cap	1.5	3.3	V
VCHAR	Supply voltage from external energy harvester	0	6	V
ICHAR	Supply current from external energy harvester VCHAR < 4 V 4 V<VCHAR<6 V		Limited internally 45	 mA
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	0	2.0	V
VIND	Voltage at RESET, WAKE0/1, and every digital input	0	3.6	V

3.6   Power management and voltage regulators

Symbol	Parameter	Conditions / Notes	Min	Typ	Max	Units
Voltage Regulators						
VDDR	Ripple on VDD, where Min(VDD) > VON				50	mV_{pp}
UVDD	Ultra Low Power supply			1.8		V
RVDD	RF supply	Internal signal only	1.7	1.8	1.9	V
DVDD	Digital supply	Internal signal only	1.7	1.8	1.9	V
Threshold Detector						
VON	Turn on threshold		2.3	2.45	2.6	V
VOFF	Turn off threshold	Automatic shutdown if VDD drops below VOFF	1.85	1.9	2.1	V

Threshold detector

STM 31x provides an internal ultra low power ON/OFF threshold detector. If VDD > VON, it turns on the ultra low power regulator (UVDD), the watchdog timer and the WAKE# pins circuitry. If VDD ≤ VOFF, it initiates the automatic shut down of STM 31x. For details of this mechanism please refer to the Dolphin Core Description documentation.

3.7 Configuration

3.7.1 Configuration via pins

The encoding input pins have to be left open or connected to GND in correspondence with the following connection schemes. These settings are checked at every wake-up.

CONF_0	CONF_1	Wake-up cycle time	Number of wake-ups that trigger a redundant retransmission
NC	NC	100 s ±20%	Every 7th - 14th timer wake-up signal, affected at random
NC	GND	10 s ±20%	Every 70th - 140th timer wake-up signal, affected at random
GND	NC	100 s ±20%	Every timer wake-up signal
GND	GND	No cyclic wake-up	No redundant retransmission

⚠️ A radio telegram is always transmitted after wake-up via WAKE pins!
After transmission the counter is reset to a random value within the specified interval.

⚠️ According to FCC 15.231a) a redundant retransmission at every timer wake-up to determine the system integrity is only allowed in safety and security applications! In this case the total transmission time must not exceed two seconds per hour, which means that a combination with a 1 s wake-up cycle time is not allowed!

If applied in other (non-safety, non-security) applications a minimum of 10 s between periodic transmissions is required. In addition the device has to comply with the lower field strength limits of 15.231e). The limited modular approval of STM 31xC is not valid in this case.
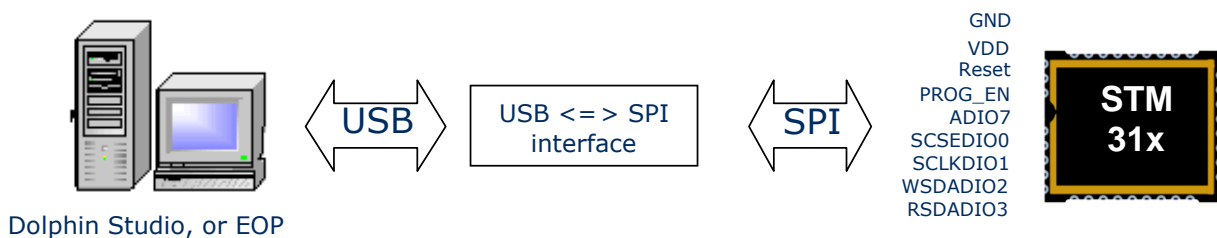
3.7.2 Configuration via serial interface

Via the programming interface the configuration area can be modified. This provides a lot more configuration options. Values set via serial interface override hardware settings! These settings are read after RESET or power-on reset only and not at every wake-up of the module!

Parameter	Configuration via pins	Configuration via serial interface
Wake up cycle	See section 3.7.1	Value can be set from 1 s to 65534 s
Redundant Retransmission cycle	See section 3.7.1	Min…Max values for random interval If Min=Max -> random switched off
Threshold values for analog inputs (transmission of telegram if threshold value exceeded)	No	The default values are: 5 LSB at AD_1 input, 6 LSB at AD_0 and 14 LSB at AD_2. The threshold value can be set between 0 and full scale for every input individually.
Resolution of the analog inputs	No	Default: AD_0: 8 bit, AD_1: 8 bit, AD_2: 8 bit Option: AD_0: 10 bit, AD_1: 6 bit, AD_2: 8 bit
Input mask	No	A digital input mask for ignoring changes on digital input pins. At default all input bits are checked.
Delay time between SWPWR on and sampling moment (for stabilization of external sensor measurement values)	No	Value can be set from 0 ms to 508 ms in steps of 2 ms. Default delay time is 2 ms.
Source of AD_2	No	Select if AD_2 contains measurement value of external ADIO2 pin or from internal VDD/4
Edge of wake pin change causing a telegram transmission	No	Every change of a wake pin triggers a wake-up. For both wake pins it can be configured individually if a telegram shall be sent on rising, falling or both edges.
Manufacturer ID and EEP (EnOcean Equipment Profile)	No	Information about manufacturer and type of device. This feature is needed for "automatic" interoperability of sensors and actuators or bus systems. Unique manufacturer IDs are distributed by the EnOcean Alliance.

The interface is shown in the figure below:

GND
VDD
Reset
PROG_EN
ADIO7
SCSEDIO0
SCLKDIO1
WSDADIO2
RSDADIO3

STM 31x

Dolphin Studio, or EOP

USB   USB <=> SPI interface   SPI

EnOcean provides EOPx (EnOcean Programmer, a command line program) and Dolphin Studio (Windows application for chip configuration, programming, and testing) and the USB/SPI programmer device as part of the EDK 300 developer´s kit.

3.8 Radio telegram

3.8.1 Normal operation

Telegram content (seen at serial interface of RCM 130/TCM 3x0 or at DOLPHIN API):

ORG   = 0x07 (Telegram type "4BS")

Data_Byte1..3
3x8bit mode:
        DATA_BYTE3   = Value of AD_2 analog input
        DATA_BYTE2   = Value of AD_1 analog input
        DATA_BYTE1   = Value of AD_0 analog input

1x8bit, 1x6it, 1x10bit mode:
        DATA_BYTE3   = Value of AD_2
        DATA_BYTE2   = Upper 2 bits of AD_0 and value of AD_1
        DATA_BYTE1   = Lower 8 bits Value of AD_0 analog input

DATA_BYTE3								DATA_BYTE2						DATA_BYTE1							
AD_2								AD_1						AD_0							
7	6	5	4	3	2	1	0	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0

DATA_BYTE0 = Digital sensor inputs as follows:
Bit 7   Bit 0

Reserved, set to 0	1	DI_2	DI_1	DI_0

ID_BYTE3   = module identifier (Byte3)
ID_BYTE2   = module identifier (Byte2)
ID_BYTE1   = module identifier (Byte1)
ID_BYTE0   = module identifier (Byte0)

The voltages measured at the analog inputs can be calculated from these values as follows:

$$U = (\text{Value of } AD\_x)/(2^n) \times 1.8 \text{ V} \qquad n = \text{resolution of channel in bit}$$
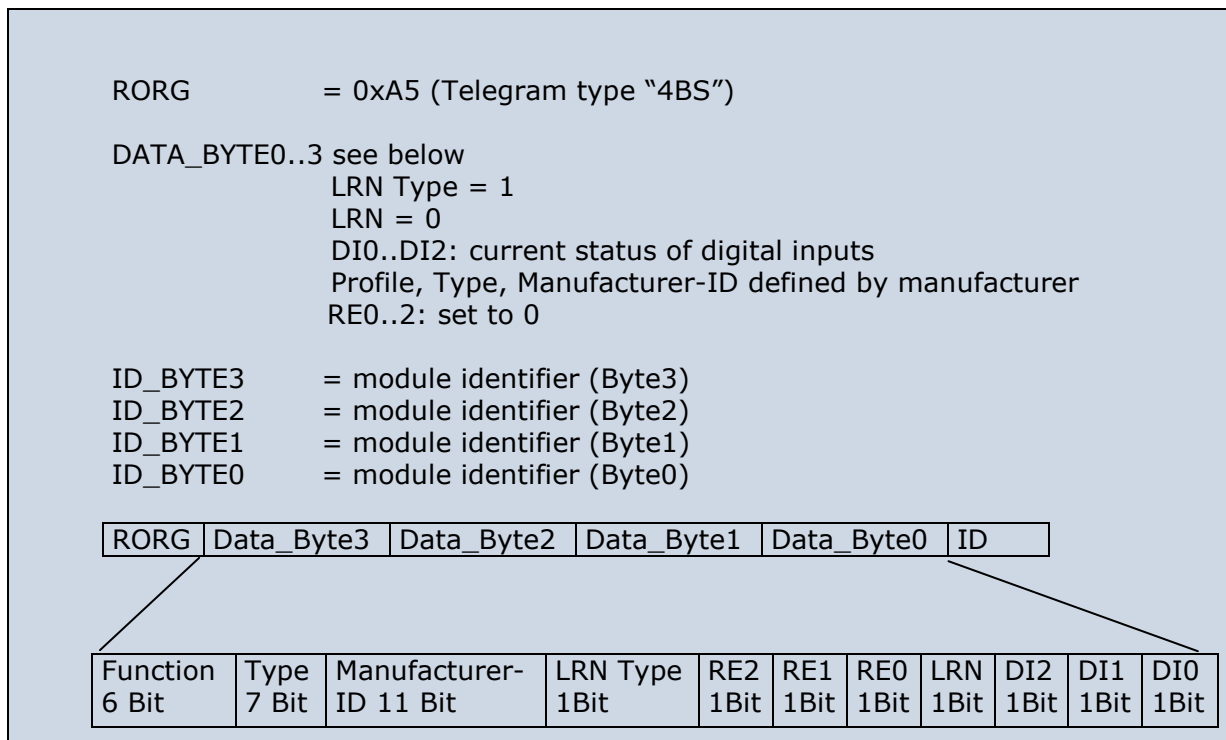
⚠ Please note the limitations in the measurement range of the A/D converter as shown in 3.3.2.

3.8.2 Teach-in telegram

In case of a wake-up via WAKE1 pin (LRN input) the module transmits a teach-in telegram.

- If the manufacturer code is not set, the module transmits a normal telegram according to 3.8.1 with the difference that DI_3=0.
- If a manufacturer code is set, this teach-in telegram contains special information as described below.

With this special teach-in telegram it is possible to identify the manufacturer of a device and the function and type of a device. There is a list available from the EnOcean Alliance describing the functionalities of the respective products.

RORG   = 0xA5 (Telegram type "4BS")

DATA_BYTE0..3 see below
        LRN Type = 1
        LRN = 0
        DI0..DI2: current status of digital inputs
        Profile, Type, Manufacturer-ID defined by manufacturer
        RE0..2: set to 0

ID_BYTE3   = module identifier (Byte3)
ID_BYTE2   = module identifier (Byte2)
ID_BYTE1   = module identifier (Byte1)
ID_BYTE0   = module identifier (Byte0)

RORG	Data_Byte3	Data_Byte2	Data_Byte1	Data_Byte0	ID

Function 6 Bit	Type 7 Bit	Manufacturer-ID 11 Bit	LRN Type 1Bit	RE2 1Bit	RE1 1Bit	RE0 1Bit	LRN 1Bit	DI2 1Bit	DI1 1Bit	DI0 1Bit

3.9   Transmit timing

The setup of the transmission timing allows avoiding possible collisions with data packages of other EnOcean transmitters as well as disturbances from the environment. With each transmission cycle, 3 identical subtelegrams are transmitted within 40 ms. The transmission of a subtelegram lasts approximately 1.2 ms. The delay between the three transmission bursts is affected at random.

⚠ If a new wake-up occurs before all sub-telegrams have been sent, the series of transmissions is stopped and a new series of telegrams with new valid measurement values is transmitted.

3.10 Charging circuitry

The figure below shows the internal charging circuit. It is controlled via the WXODIO pin of EO3000I which switches according to the status of the internal threshold detector. For details please refer to our Dolphin Core Description documentation. The WXIDIO pin is used to disconnect the energy storage element at voltages below VOFF to avoid deep discharge.
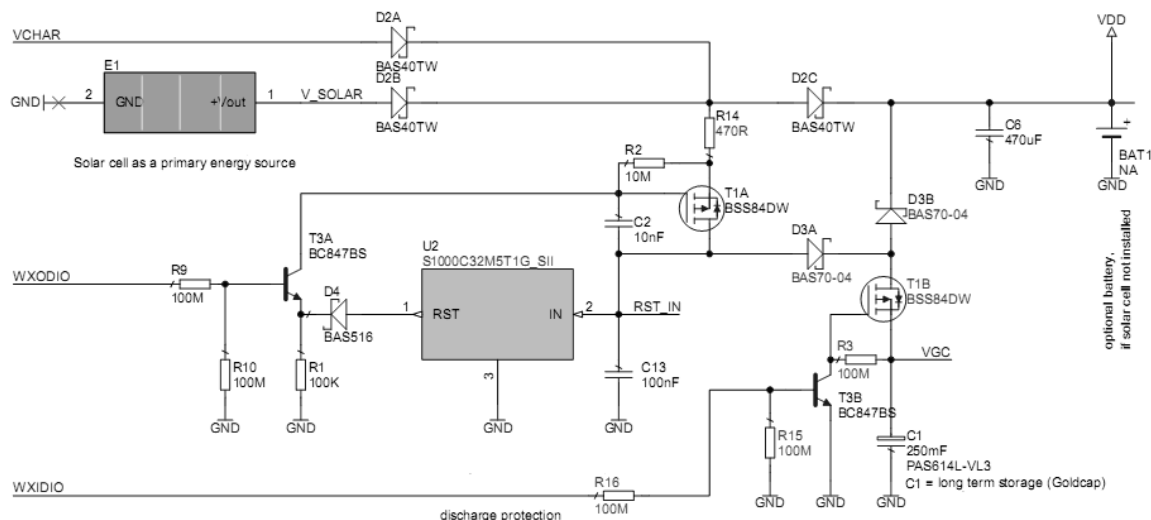
An external 3 V backup battery can be connected at VDD (STM 312 only, see 4.4) or at VCHAR.

3.11 Energy consumption
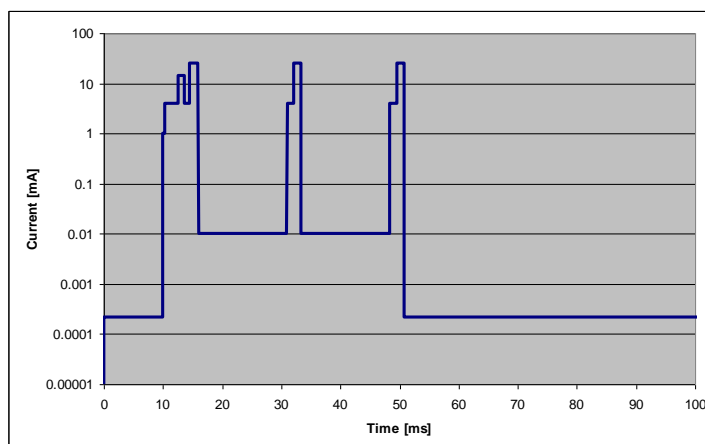
Current Consumption of STM 31x

Charge needed for one measurement and transmit cycle: ~130 µC
Charge needed for one measurement cycle without transmit: ~30 µC
(current for external sensor circuits <1 mA)

Calculations are performed on the basis of electric charges because of the internal linear voltage regulator of the module. Energy consumption varies with voltage of the energy storage while consumption of electric charge is constant.

From these values the following typical performance parameters at room temperature have been calculated:

Wake cycle [s]	Transmit interval	Operation Time in darkness [h] when storage fully charged	Required reload time [h] at 200 lux within 24 h for continuous operation	24 h operation after 6 h illumination at x lux	Illumina-tion level in lux for continuous operation	Current in µA required for con-tinuous operation
1	1	0.5	storage too small	storage too small	5220	130.5
1	10	1.7	storage too small	storage too small	1620	40.5
1	100	2.1	storage too small	storage too small	1250	31.3
10	1	5.1	storage too small	storage too small	540	13.5
10	10	16	21	storage too small	175	4.4
10	100	20	16.8	storage too small	140	3.5
100	1	43	7.8	260	65	1.6
100	10	98	3.6	120	30	0.8
100	100	112	3	100	25	0.6

Assumptions:
- Internal storage PAS614L-VL3 (after several days of operation at good illumination level) with 0.25 F, Umax=3.2 V, Umin=2.2 V, T=25 °C
- Consumption: Transmit cycle 100 µC, measurement cycle 30 µC; including consumption of external sensor circuitry <1 mA
- Pre-installed solar cell ECS 300, operating values 3 V and 5 µA @ 200 lux fluorescent light
- Current proportional to illumination level (not true at very low levels!)

These values are calculated, the accuracy is about +/-20%! The performance varies over temperature and may be strongly reduced at extreme temperatures or short transmit inter-vals.

4 APPLICATIONS INFORMATION

4.1 Using the WAKE pins

The logic input circuits of the WAKE0 and WAKE1 pins are supplied by UVDD and therefore also usable in "Deep Sleep Mode". Due to current minimization there is no internal pull-up or pull-down at the WAKE pins. When STM 31x is in "Deep Sleep Mode" and the logic levels of WAKE0 and / or WAKE1 is changed, STM 31x starts up.

As the there is no internal pull-up or pull-down at the WAKE0 pin, it has to be ensured by external circuitry, that the WAKE0 pin is at a defined logic level at any time. At time of delivery a jumper is connected between WAKE0 and UVDDext. WAKE1 provides an internal 1.8 MΩ pull-up. See figure below.
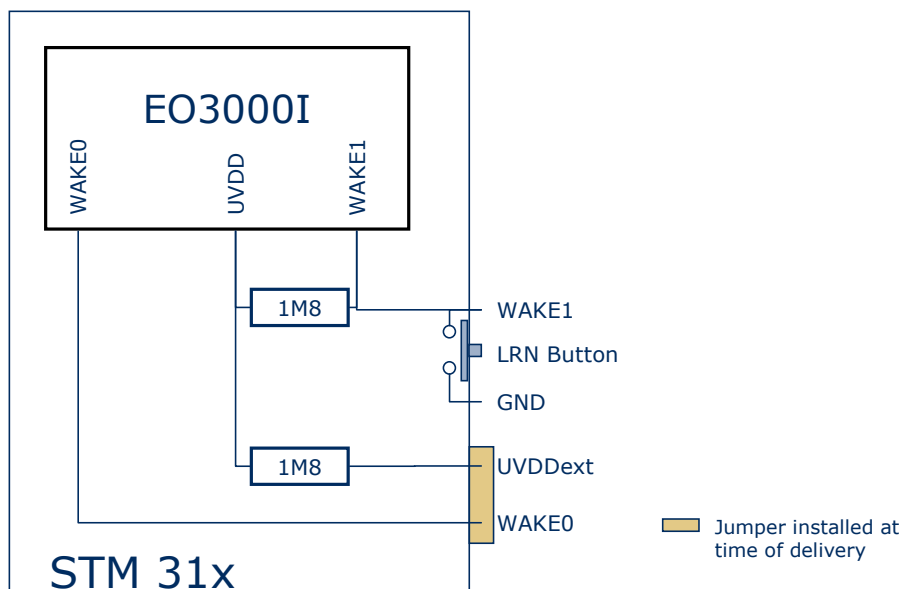

When the LRN button is pressed WAKE1 is pulled to GND and a teach-in telegram is transmitted. As long as the button is pressed a small current of approximately 1 µA is flowing. It is possible to connect an additional external button in parallel between WAKE1 and GND if a different position of the button in the device is required.

WAKE0 is connected to UVDDext via a jumper at time of delivery. If the module is mounted onto a host PCB the jumper has to be removed. The circuitry on the host PCB then has to ensure that WAKE0 is always in a defined position. There are two ways to use WAKE0:

■ Connect WAKE0 to UVDDext and connect an external button between WAKE0 and GND. As long as the button is pressed a current of 1 µA will flow.
■ Connect a 3 terminal switch and switch WAKE0 to either GND or UVDDext. In this case there is no continuous flow of current in either position of the switch.

If more digital inputs with WAKE functionality are needed in an application, WAKE0 can be combined with some of the digital inputs as shown below:
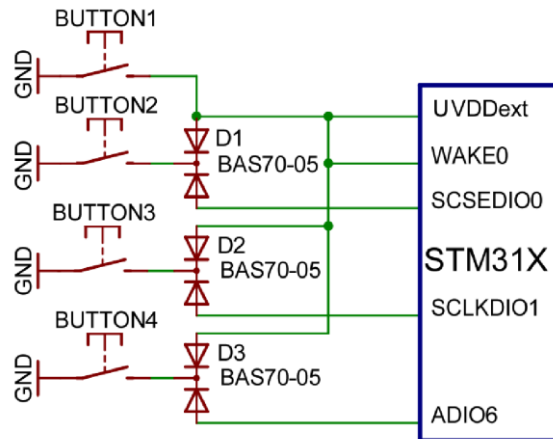
4.2   Analog measurement

The EO3000I chip inside STM31x cannot measure rail-to-rail. Therefore an adaptation of the external sensor circuit is required. Two offset voltages REFN and REFP – which are within the measurement range of EO3000I – have to be generated and buffered by voltage followers as shown below. The offset voltages are defined by a resistor divider. Resistors with a tolerance of 1% or less are recommended.

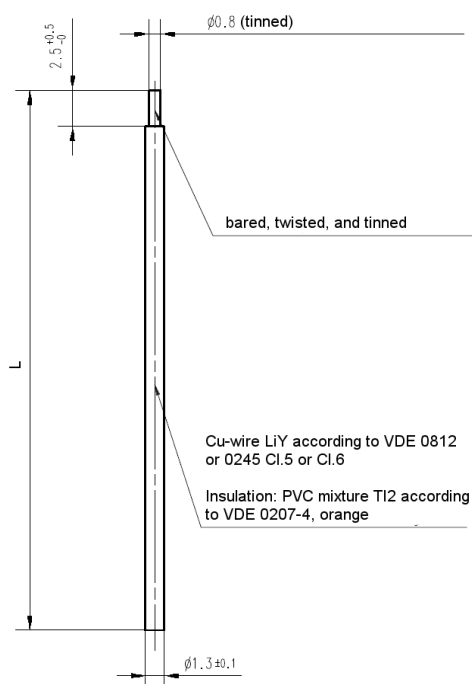The sensor circuit must be designed to output voltages between REFN (=0) and REFP (full scale).
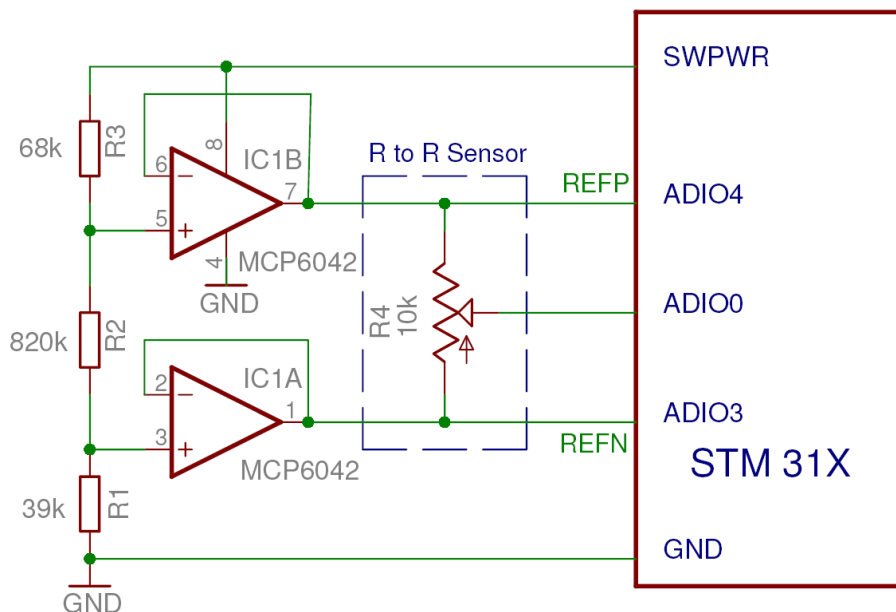
Example for connection of a sensor to ADIO0
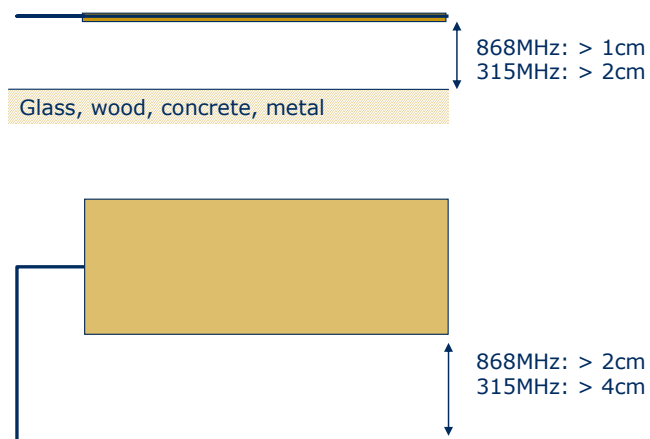
4.3   Antenna options

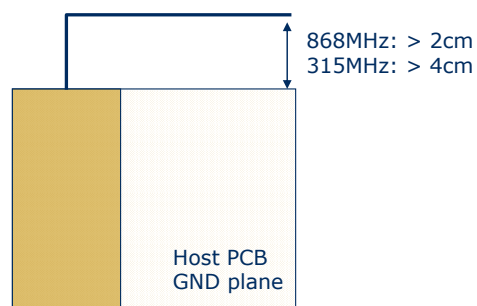### 4.3.1 Whip antenna (STM 310, STM 310C, STM 312, STM 312C)

Specification of the whip antenna; L=150 mm @ 315 MHz, L=86 mm @ 868 MHz
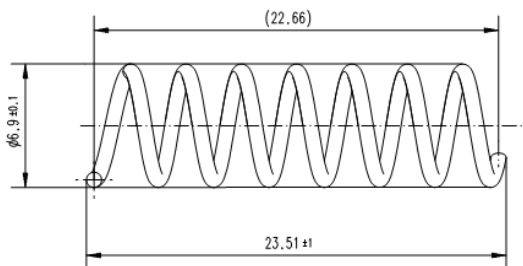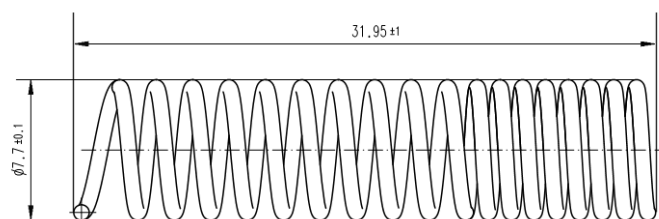
Antenna layout recommendation:

STM 31x without host PCB

Glass, wood, concrete, metal

868MHz: > 1cm
315MHz: > 2cm

868MHz: > 2cm
315MHz: > 4cm

STM 31x with host PCB

Host PCB
GND plane

868MHz: > 2cm
315MHz: > 4cm

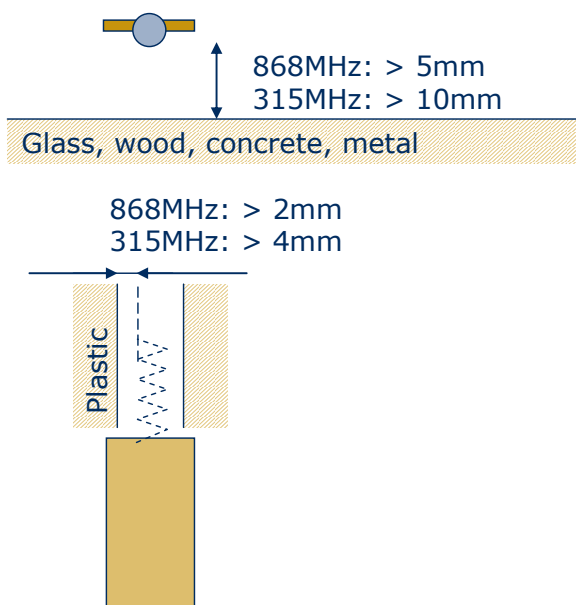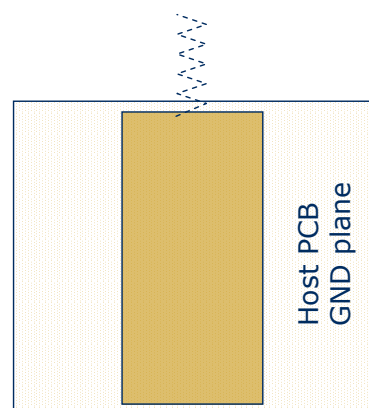### 4.3.2 Helical antenna (STM 311, STM 311C)

868 MHz

315 MHz

Antenna recommendation:

STM 31x without host PCB

STM 31x with host PCB

868MHz: > 5mm
315MHz: > 10mm

Glass, wood, concrete, metal

868MHz: > 2mm
315MHz: > 4mm

Plastic

Host PCB
GND plane

## 4.4　Mounting ECT 310 or a battery (STM 312 / STM 312C only)

STM 312 provides solder pads for ECT 310 or for a battery holder for CR16xx batteries.

ECT 310 is a low-cost ultra-low-voltage DC/DC converter for powering battery-less EnOcean radio modules by thermal energy. Operation starts at typ. 20 mV relating to a 2 K temperature difference at a standard low-cost Peltier element.
ECT 310 can be mounted as shown in this figure:
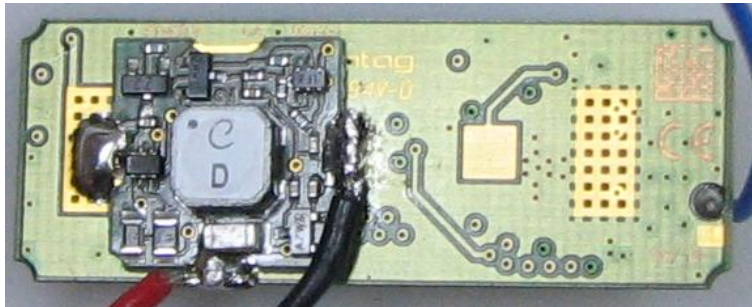
A battery holder can be mounted onto the pads shown in this figure :
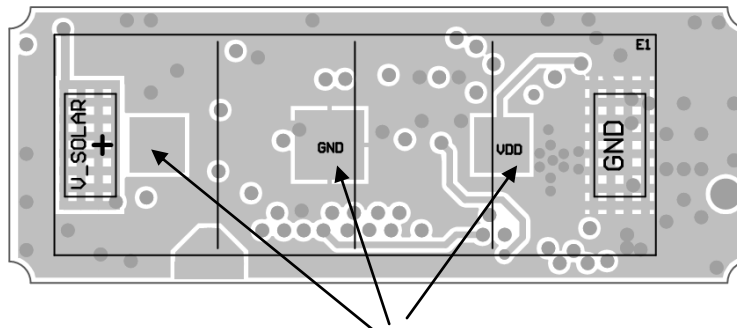
Pads for battery holder

⚠ If a battery is mounted here it is not allowed to connect an energy harvester via VCHAR! Otherwise the battery would be charged! See circuitry in 3.10.

4.5   Mounting STM 31x into a housing

The figure below shows an example of a housing in which the module can be mounted (with antenna pointing to the left). Design data of the housing and the modules is available in .igs format.
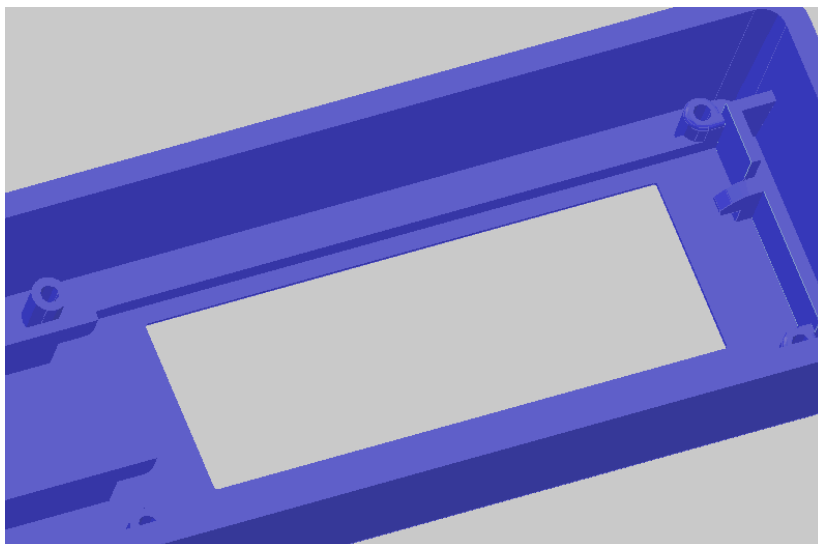
⚠ Please make sure not to exert shear force (side force within the plane of the solar cell) onto the solar cell! The maximum vertical force onto the solar cell must not exceed 4 N and should be homogeneously distributed! Bending of the PCB must be avoided!

⚠ Please make sure that the housing covers 0.5 mm at the solar cell edges. Within 0.5 mm off the edge flaking is possible due to the cutting process.

4.6   Transmission range

The main factors that influence the system transmission range are type and location of the antennas of the receiver and the transmitter, type of terrain and degree of obstruction of the link path, sources of interference affecting the receiver, and "Dead" spots caused by signal reflections from nearby conductive objects. Since the expected transmission range strongly depends on this system conditions, range tests should categorically be performed before notification of a particular range that will be attainable by a certain application.

The following figures for expected transmission range are considered by using a PTM, a STM or a TCM radio transmitter device and the TCM radio receiver device with preinstalled whip antenna and may be used as a rough guide only:

- Line-of-sight connections: Typically 30 m range in corridors, up to 100 m in halls
- Plasterboard walls / dry wood: Typically 30 m range, through max. 5 walls
- Ferroconcrete walls / ceilings: Typically 10 m range, through max. 1 ceiling
- Fire-safety walls, elevator shafts, staircases and supply areas should be considered as screening.

The angle at which the transmitted signal hits the wall is very important. The effective wall thickness – and with it the signal attenuation – varies according to this angle. Signals should be transmitted as directly as possible through the wall. Wall niches should be avoided. Other factors restricting transmission range:

- Switch mounted on metal surfaces (up to 30% loss of transmission range)
- Hollow lightweight walls filled with insulating wool on metal foil
- False ceilings with panels of metal or carbon fiber
- Lead glass or glass with metal coating, steel furniture

The distance between EnOcean receivers and other transmitting devices such as computers, audio and video equipment that also emit high-frequency signals should be at least 0.5 m.

A summarized application note to determine the transmission range within buildings is available as download from www.enocean.com.

5   AGENCY CERTIFICATIONS

The modules have been tested to fulfil the approval requirements for CE (STM 31x) and FCC/IC (STM 31xC) based on the built-in firmware.

When developing customer specific firmware based on the API for this module, special care must be taken not to exceed the specified regulatory limits, e.g. the duty cycle limitations!

5.1   CE Approval

The STM 31x module bears the EC conformity marking CE and conforms to the R&TTE EU-directive on radio equipment. The assembly conforms to the European and national requirements of electromagnetic compatibility. The conformity has been proven and the according documentation has been deposited at EnOcean. The modules can be operated without notification and free of charge in the area of the European Union and in Switzerland.

- EnOcean RF modules must not be modified or used outside their specification limits.
- EnOcean RF modules may only be used to transfer digital or digitized data. Analog speech and/or music are not permitted.
- EnOcean RF modules must not be used with gain antennas, since this may result in allowed ERP or spurious emission levels being exceeded.
- The final product incorporating EnOcean RF modules must itself meet the essential requirement of the R&TTE Directive and a CE marking must be affixed on the final product and on the sales packaging each. Operating instructions containing a Declaration of Conformity has to be attached.
- If the STM 31x transmitter is used according to the regulations of the 868.3 MHz band, a so-called "Duty Cycle" of 1% per hour must not be exceeded. Permanent transmitters such as radio earphones are not allowed.
- The module must be used with only the following approved antenna(s).

Model	Type
STM 310 STM 312	Pre-installed Wire/Monopole
STM 311	Pre-installed helical antenna

5.2   FCC (United States) certification

STM 31xC LIMITED MODULAR APPROVAL

This is an RF module approved for Limited Modular use operating as an intentional transmitting device with respect to 47 CFR 15.231(a-c) and is limited to OEM installation. The module is optimized to operate using small amounts of harvested energy, such as can be collected by a small solar cell exposed to ambient light. The module transmits short radio packets comprised of control signals, (in some cases the control signal may be accompanied with data) such as those used with alarm systems, door openers, remote switches, and the like. The module does not support continuous streaming of voice, video, or any other forms of streaming data; it sends only short packets containing control signals and possibly data and is typically powered by a solar cell in ambient light. The module is designed to comply with, has been tested according to 15.231(a-c), and has been found to comply with each requirement. Thus, a finished device containing the STM 31xC radio module can be operated in the United States without additional Part 15 FCC approval (approval(s) for unintentional radiators may be required for the OEM's finished product), under EnOcean's FCC ID number. This greatly simplifies and shortens the design cycle and development costs for OEM integrators.

The module can be triggered manually or automatically, which cases are described below.

Manual Activation

The radio module can be configured to transmit a short packetized control signal if triggered manually. The module can be triggered, by pressing a switch, for example. The packet contains one (or more) control signals that is(are) intended to control something at the receiving end. The packet may also contain data. Depending on how much energy is available from the energy source, subsequent manual triggers can initiate the transmission of additional control signals. This may be necessary if prior packet(s) was (were) lost to fading or interference. Subsequent triggers can also be initiated as a precaution if any doubt exists that the first packet didn't arrive at the receiver. Each packet that is transmitted, regardless of whether it was the first one or a subsequent one, will only be transmitted if enough energy is available from the energy source.

Automatic Activation

The radio module also can be configured to transmit a short packetized control signal if triggered automatically, by a relevant change of its inputs, for example. Again, the packet contains a control signal that is intended to control something at the receiving end and may also contain data. As above, it is possible for the packet to get lost and never reach the receiver. However, if enough energy is available from the energy source, and the module has been configured to do so, then another packet or packets containing the control signal may be transmitted at a later, unpredictable time.

OEM Requirements

In order to use EnOcean's FCC ID number, the OEM must ensure that the following conditions are met.

- End users of products, which contain the module, must not have the ability to alter the firmware that governs the operation of the module. The agency grant is valid only when the module is incorporated into a final product by OEM integrators.

- The end-user must not be provided with instructions to remove, adjust or install the module.

- The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product. Attaching a label to a removable portion of the final product, such as a battery cover, is not permitted. The label must include the following text:

  STM 310C, STM 312C:

  Contains FCC ID: SZV-STM310C
  The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.

  STM 311C:

  Contains FCC ID: SZV-STM311C
  The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.

  When the device is so small or for such use that it is not practicable to place the statement above on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

  The user manual for the end product must also contain the text given above.

- Changes or modifications not expressly approved by EnOcean could void the user's authority to operate the equipment.

- The OEM must ensure that timing requirements according to 47 CFR 15.231(a-c) are met.

- The OEM must sign the OEM Limited Modular Approval Agreement with EnOcean

- The module must be used with only the following approved antenna(s).

Model	Type	Gain
STM 310C STM 312C	Pre-installed Wire/Monopole	1.0 dBi
STM 311C	Pre-installed helical antenna	-9 dBi

5.3 IC (Industry Canada) certification

In order to use EnOcean's IC number, the OEM must ensure that the following conditions are met:

- Labeling requirements for Industry Canada are similar to those required by the FCC. The Original Equipment Manufacturer (OEM) must ensure that IC labeling requirements are met. A clearly visible label on the outside of a non-removable part of the final product must include the following text:
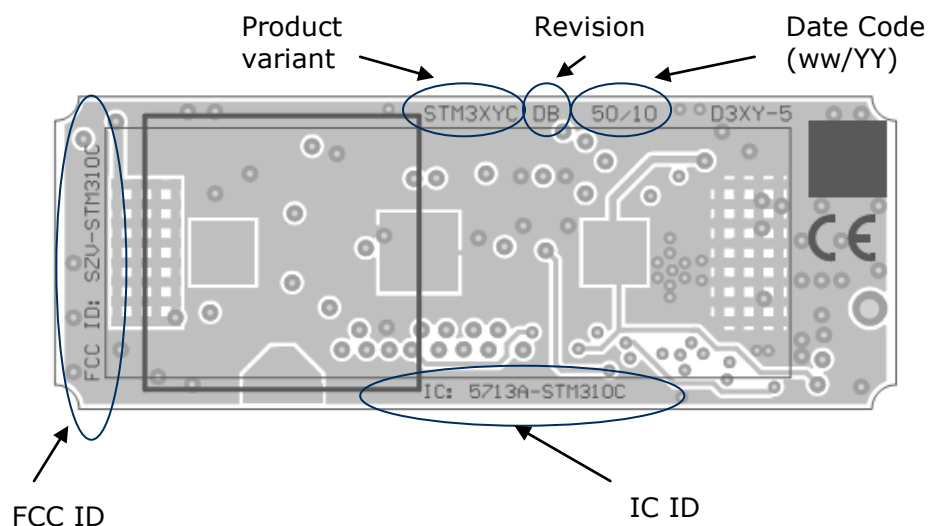
  STM 310C, STM 312C:

  Contains IC: 5713A-STM310C

  STM 311C

  Contains IC: 5713A-STM311C

- The OEM must sign the OEM Limited Modular Approval Agreement with EnOcean

6   Label Information

7   Circuit diagram

The figure below depicts a simplified circuit diagram of STM 31x.